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LARVAL FISH OF SELECTED AQUATIC HABITATS ON THE LOWER MISSISSIPPI RIVER

By John V. Conner, C. H. Pennington, Timothy R. Bosley

Environmental Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

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A study of larval fishes in the Lower Mississippi River, river miles 505-525, was conducted from April through October 1980. The objectives of this study were to assess the relative importance of dike fields, revetted banks, and other habitats to fish larvae and to characterize the seasonal changes in local distribution of ichthyoplankton within a dike field. With respect to larval fish ecology, the results of this study may be representative of the Lower Mississippi River mainstream in general.

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20. ABSTRACT (Continued).

Shads and herrings were abundant and common in all locations, while other taxa exhibited clear affinities for certain habitats. Matthews Bend (an abandoned channel) was the most distinctive habitat sampled. Its ichthyoplankton community consisted essentially of shads and sunfishes and lacked fishes that were abundant in all other habitats. At times, other than apparent spawning peaks in Matthews Bend, the main-stem habitats yielded equal or higher catches of larvae.

Qualitative trends indicated a basic dichotomy among the six main-stem locations. During high and moderate river stages, shad dominated the collections at all main-stem locations. The principal differences among main-stem locations became manifest during the period of lower river stages. Drums, carpsuckers, and minnows dominated in main-channel locations, while sunfishes and shads prevailed in collections from off-channel locations.

The Lower Cracraft Dike Field exhibited variability in larval fish diversity and abundance throughout the spawning season. During high to moderate river stage conditions (April through June), larval fish diversity was high and abundance was greater at open water stations than nearshore stations. Moderate to low river stage conditions occurred from July through October. The diversity of larval fishes was fairly low at this time, as it was in all major habitats. Under low water conditions the dike field ichthyoplankton community is actually two communities. The greatest concentrations tended to be inside the middle bar, especially along the shoreline rather than in the open pool. Fishes inside the middle bar were mainly shads, bluegill, and silversides. The community along the riverside of the middle bar is not substantially different from that of the main channel.

PREFACE

The study described in this report was sponsored by the Office, Chief of Engineers, U. S. Army, under the Environmental and Water Quality Operational Studies (EWQOS) Program, Work Unit VIIB, Waterway Field Studies. The EWQOS Program has been assigned to the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., under the direction of the Environmental Laboratory (EL).

This report presents results of a study designed to document the distribution and relative abundance of ichthyoplankton associated with five different habitats found within the main-line levees along the Lower Mississippi River. Larval fish were collected from the river between miles 505 and 525 during April-October 1980.

The report was prepared by Drs. John V. Conner and C. H. Pennington and Mr. Timothy R. Bosley under the supervision of Dr. Thomas D. Wright, Chief, Aquatic Habitat Group; Mr. Bob O. Benn, Chief, Environmental Systems Division; Dr. Jerome L. Mahloch, Program Manager, EWQOS; and Dr. John Harrison, Chief, EL.

Special appreciation is expressed to Mr. Michael E. Potter for carrying out all phases of field support; Miss Carolyn L. Bond for data management; and Drs. Michael P. Farrell and Douglas S. Vaughan, Oak Ridge National Laboratory, for assistance with data analyses. Fish larvae were identified by personnel of the Louisiana Cooperative Fishery Research Unit under Intra-Army Order No. WESRF 78-157 dated 16 March 1978.

Commanders and Directors of WES during the study and the preparation of this report were COL Nelson P. Conover, CE, and COL Tilford C. Creel, CE. Technical Director was Mr. Fred R. Brown.

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CONTENTS

LARVAL FISH OF SELECTED AQUATIC HABITATS ON THE LOWER MISSISSIPPI RIVER

PART I: INTRODUCTION

Background

1. This investigation is part of the Environmental and Water Quality Operational Studies (EWQOS) Program sponsored by the Office, Chief of Engineers, and managed by the U. S. Army Engineer Waterways Experiment Station (WES). The basic objective of the EWQOS Program is to provide technology for the planning, design, and operation of Corps of Engineers (CE) projects to improve environmental quality. One major problem area identified by CE field offices as being of high priority was the environmental impacts of project activities on waterways (Keeley et al. 1978).

2. Because of the abundance of channel alignment structures on the Lower Mississippi River, a study was initiated to provide ecological information about these structures. The general purpose of the Mississippi River Study is to investigate the ecological role of dikes and revetments. The work is being specifically conducted to document the significance of dikes and revetments as habitat for macroinvertebrates and fish.

Dikes and Revetments

3. Dikes have been used by the CE for many years on the Nation's waterways to adjust channel width, depth, and alignment, as well as to close secondary channels. They are constructed of permeable wooden piles or, more typically in present times, of relatively impermeable stone riprap. They may be solitary or placed one after another along a bank forming a dike field. Generally, dikes in the Lower Mississippi River are of the transverse type which extend from the bank perpendicular to the current.

4. Revetments are installed along riverbanks to prevent bank caving and erosion. These structures are of many types, but generally consist of erosion-resistant materials placed on a pregraded bank from the top of the bank line to the toe of the channel. When riverbanks are revetted, much of their natural character is altered and the environmental quality of the habitat formed is poorly known.

5. As of 30 September 1980, there were more than 400 dikes along the Lower Mississippi River having a combined length of 296 km. In addition, there are 1252 km of revetted bank. Under the Mississippi River and Tributaries (MR&T) Project, the CE has an additional 180 km of dikes and 305 km of revetment planned for placement before November 1996.

Objectives

6. This study was conducted to determine the relative abundance of larval fish in dike fields, revetted banks, and other habitats found in the Lower Mississippi River and to characterize the seasonal changes in local distribution of ichthyoplankton within a dike field.

PART II: METHODS

Study Area

7. The study area encompassed a 32-km reach of the Lower Mississippi River (Figure 1) south of Greenville, Miss. (river miles 505 to 525). This reach is confined on both sides by main-line levees constructed by the CE for flood control. Leveed floodplain width ranges from 3.2 to 9.6 km. Backwater habitats between the levees and the main river channel have indirect or seasonal connections with the river and

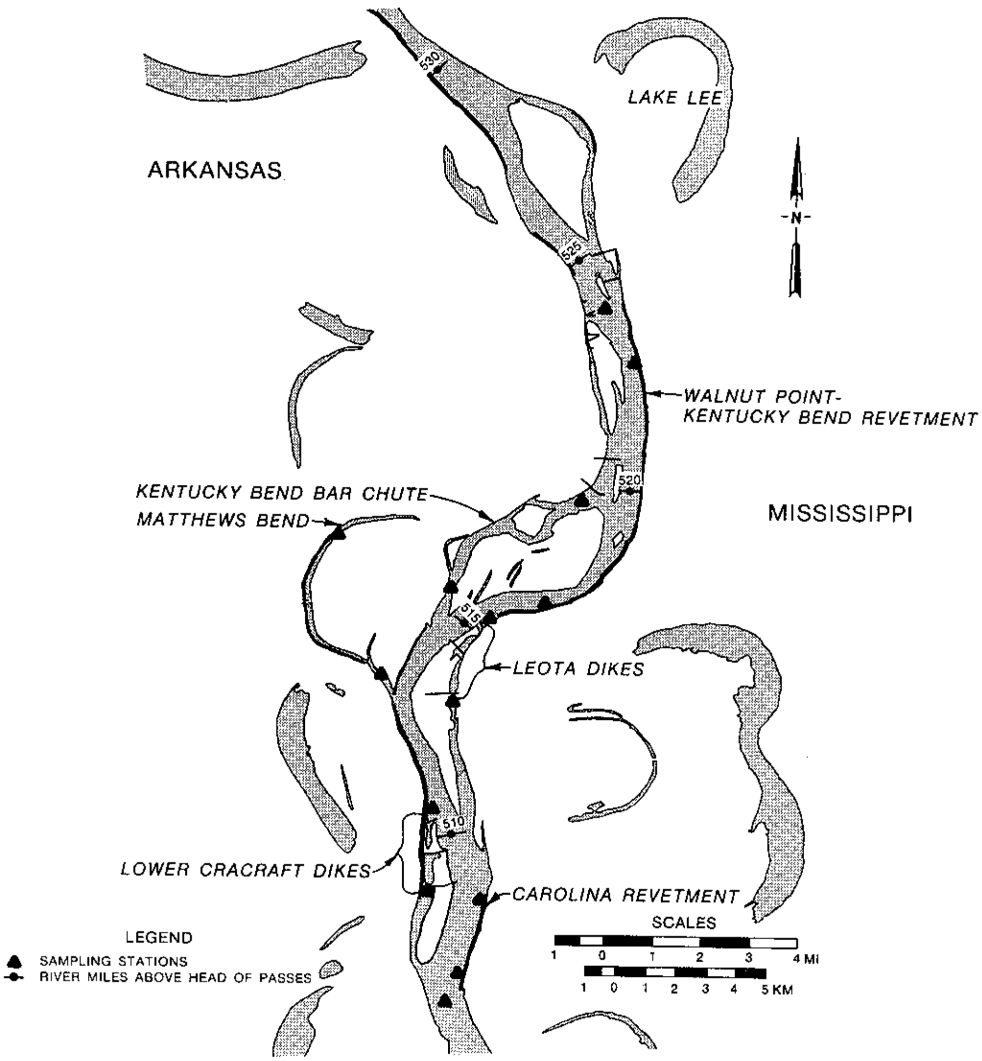

Figure 1. Map of study with sampling stations indicated

are submerged during floods. No tributaries enter the river in the study area. The study area is considered to be typical of the Lower Mississippi River upstream of Baton Rouge, La; reasons for selection of this reach are documented by Miller (1980) and Cobb and Clark (1981).

8. At Vicksburg, Miss., a major gaging and data collection point for the Lower Mississippi River located 104 km downstream from the study area, average discharge is about 15,876 m^3/sec. Recorded discharges have ranged from about 2,830 m^3/sec at extreme low river stage to 76,410 m^3/sec at high stages, with an 18.7-m difference in water level. The average water velocity within the main channel is from 0.9 to 1.9 m/sec with a maximum recorded velocity of 4.7 m/sec during extremely high flows. The average hydrograph for the river at Vicksburg shows highest discharge occurring from February through March and lowest discharge from July through October. Except for a slightly delayed and attenuated period of high water, 1980 was fairly typical for the lower river (Figure 2).

Sampling Scheme

9. Spawning and larval development of fishes occurs over an extended period from spring through early autumn in the Lower Mississippi River (Gallagher and Conner 1980, Schramm and Pennington 1981). Therefore, sampling was conducted over an 8-month period from March through October 1980 to completely assess the diversity, abundance, and distribution of ichthyoplankton in the study area.

Habitat comparisons

10. Seven locations representing five habitats found in the study area were chosen for sampling. The habitats sampled were the main river channel, a temporary secondary channel, an abandoned channel, dike fields, and revetted banks. Two stations within each of the locations were sampled (Figure 1). Detailed descriptions of the habitats are given by Cobb and Clark (1981) and Miller (1981).

11. Main channel stations were within the permanent navigation channel, roughly at opposite ends of the study reach (river miles 506 and 524).

12. The temporary secondary channel habitat was represented by

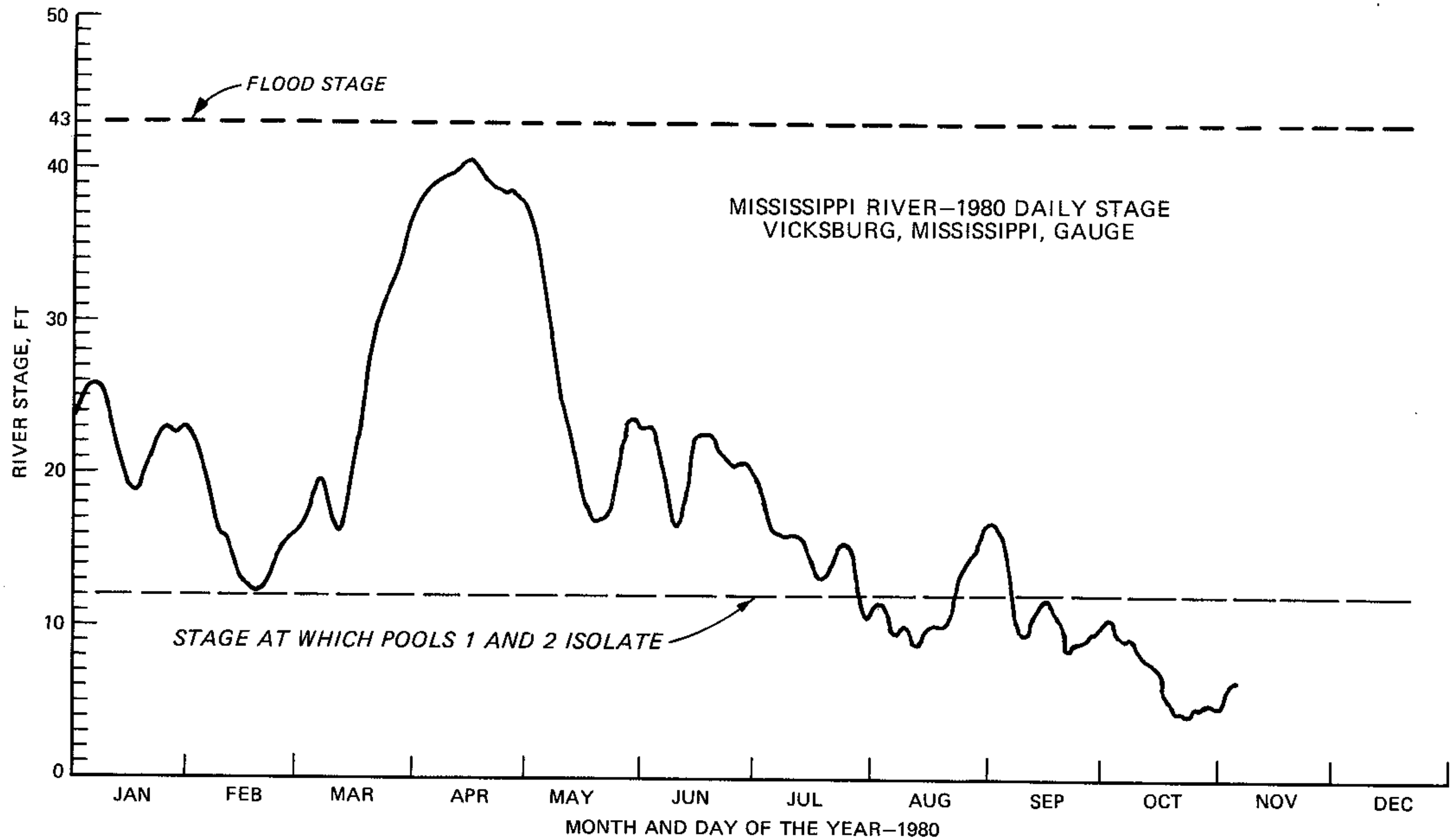

Figure 2. Hydrograph of the Mississippi River at Vicksburg, Miss., for 1980

Kentucky Bend Bar Chute, with stations located at the upstream and downstream ends. At low river stages there was no flow through the secondary channel and sampling was not always possible at both stations.

13. Matthews Bend is an abandoned river channel which is connected to the river at its downstream end during all but extremely low river stages. Stations were located at midstream in the upper and lower ends of Matthews Bend.

14. The dike field habitat was represented by the Leota (river miles 513 to 515) and Lower Cracraft Dike Fields (river miles 506 to 511). Both dike fields consist of three transverse stone dikes with extensive sand and gravel middle bars which run parallel to the bank and extend downstream along the outer edges of the dikes. Stations for habitat comparisons were located just offshore in the area above the first dike and in the open pool area below the third dike in each field (Figure 3). Currents in the dike field varied from slack or standing water at low river stages to almost as swift as those of the main channel at high stages. Extreme sedimentation downstream of each dike in the Leota field has created small, shallow isolated pools between the dikes at low water stages that were inaccessible to sampling during much of the summer and early autumn. Although isolated or semi-isolated at low river stages, the pools of Lower Cracraft Dike Field remained large and deep enough for sampling.

15. Revetted banks were represented by the Walnut Point (river miles 516.5 and 523.0) and Carolina Revetments (river miles 506.5 and 508.5). Both revetments are of articulated concrete mattress with riprap/asphalt upper bank paving.

16. Collections of fish larvae for habitat comparison were conducted at 2-week intervals, with all stations sampled between 0900 and 1430 hr on the same day (except Leota Dike Field in early September). Table 1 summarizes the spatio-temporal distribution of sampling, with mid-March and early April omitted since no fish larvae were caught on these visits.

Dike field distribution

17. Intensive sampling was conducted monthly in the Lower Cracraft

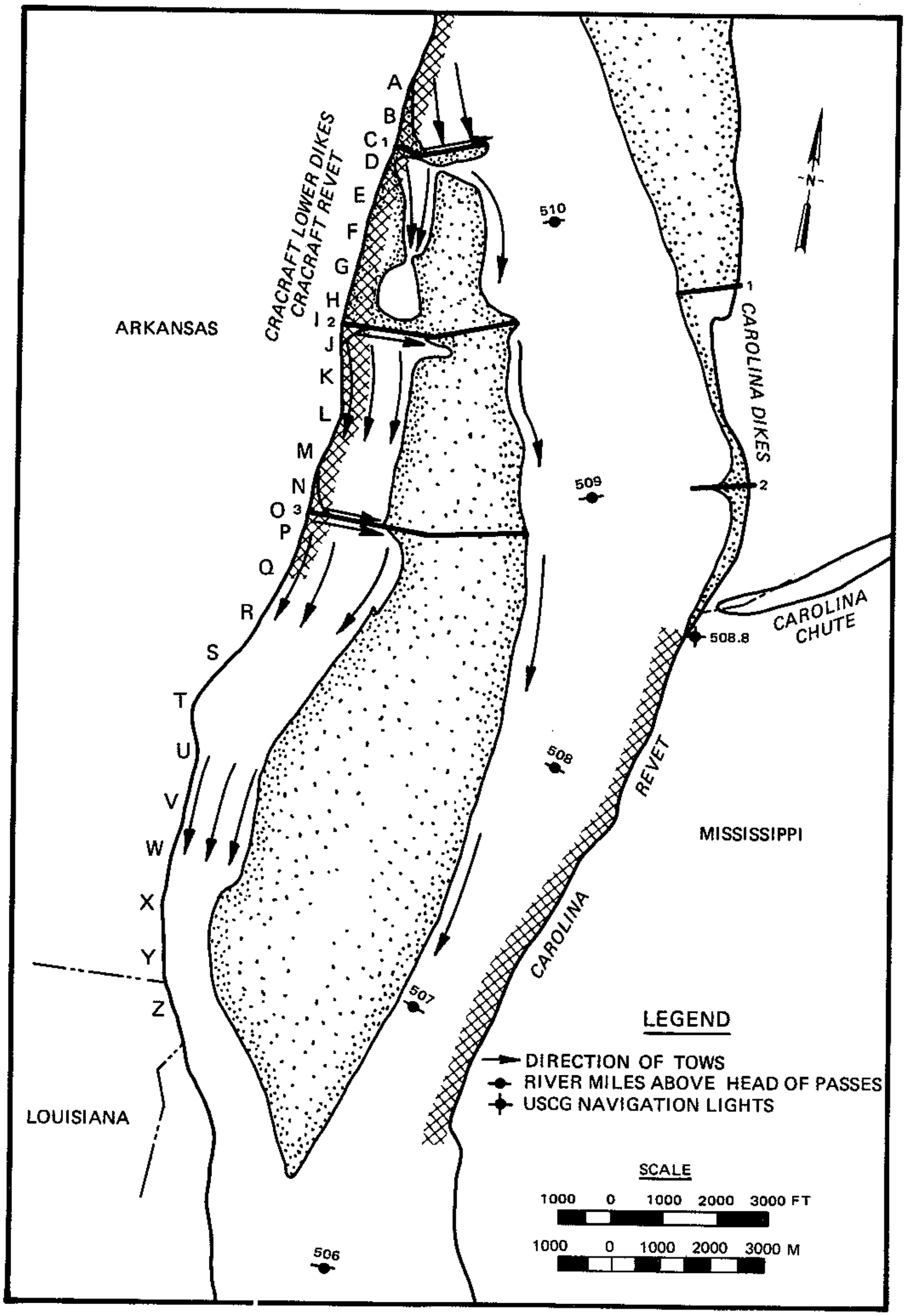

Figure 3. Map of the Cracraft Dike field showing station locations and direction of tows during low flow conditions (USCG = U. S. Coast Guard)

Dike Field. Station placement within the dike field was dependent upon river stage, but there were three stations arrayed across transects associated with the pools between dikes (Figure 3 and Table 2). There was a transect in the open area above the first dike and two transects were established in the lowermost pool because of its large size. Transect stations were used for net pushes made parallel to the banks and the river channel. Attempts were also made to sample along and immediately adjacent to the dikes (i.e., perpendicular to the long axis of the dike field), but continuity of these efforts was only possible at the second and third dikes, mainly during moderate to low river stages (Table 2).

Description and Use of Gear

18. Samples were collected in pairs with 0.5-m-diam conical nets having 0.505-mm nylon mesh. The nets were fitted with a yoke on an aluminum handle and fished 0.5 m below the water surface, 1 m away from the side of the boat at midship. The nets could be quickly raised and lowered into the water; their mouths were unobstructed by towing bridles; and they were positioned away from any bow wake or propwash of the sampling vessel.

19. Each pair of samples was taken simultaneously; one off the starboard side of the boat, the other off the port side. A General Oceanics Model 2030 flowmeter was mounted in the center of the mouth of each net to estimate the volume of water filtered. Sample time was generally of 5-min duration with the boat moving about 70 cm/sec faster than the current (if any). With the exception of the samples taken along the dikes, all samples were taken with the boat moving in a downstream direction.

20. After each sample, the nets were rinsed to flush all larval fish into the cod end plankton bucket. Contents of the bucket were then transferred to jars and immediately fixed in 10-percent buffered formalin.

Analyses and Presentation of the Data

21. Each sample was processed under a dissecting microscope by examining a small portion at a time until all fish eggs, larvae, and juveniles had been removed. So few eggs and juveniles were encountered that only larvae (i.e., posthatching stages with visible finfold tissue; Snyder, Snyder, and Douglas 1977) will be considered in this report. Larvae were sorted, counted, and identified to the lowest possible taxon by means of comparisons to reference series, laboratory notes, and appropriate literature. All material was transferred to 3- to 5-percent buffered formalin for permanent storage in the Louisiana State University Fisheries Collection of the School of Forestry and Wildlife Management.

22. Results were reported as catch per unit of effort, per 100 m^3 of water filtered as estimated from flowmeter readings. In the case of the habitat comparisons, stations representing the locations (e.g., main channel or Carolina Revetment) were pooled to yield arithmetic means. That is, the catch per effort for the main channel on a given visit is the mean of all four samples (replicates from each of two stations). No attempt was made to relate differences in abundance and species composition to physical characteristics (i.e., temperature, turbidity, cover, depth, and flow) of the habitats sampled. The dike field distributional data are station means except in the case of the exposed offshore area above the first dike throughout the study and offshore areas of all transects during high river stages (Table 2).

PART III: RESULTS AND EVALUATION

Ichthyoplankton Composition

23. During this study, 16,299 fish larvae were collected. Nearly all (99.8 percent) of these specimens were recognizable to the family level, about 90 percent could be confidently assigned to genus, and roughly half were identified to species. To retain as much information as possible while acknowledging the uncertainty of many individual identifications, 16 "kinds" or taxonomic groupings of larvae were recognized for presentation and discussion of the data (Table 3). At least 26 and perhaps as many as 37 species were represented among the larvae fish collected during 1980.

24. Overall qualitative composition of the ichthyoplankton is best illustrated by relative abundances and frequencies of occurrence of the various kinds of larvae during the habitat comparison phase of sampling, wherein roughly equal effort was exerted across all locations from mid-April through mid-October (Table 4). Shads and herring (mainly *Dorosoma* spp.); sunfishes (*Lepomis* spp., mainly blue gill); freshwater drum (*Aplodinotus grunniens*); and carpsuckers (*Carpiodes* spp., mainly river carpsucker) constituted 95 percent of all larvae.

25. The catches were composed of essentially the same taxa as those encountered in the same general study area in 1978 (Schramm and Pennington 1981); however, clupeids (shads and herring) and carpsuckers were generally more common and abundant in 1980. Among less prominent taxa, goldeyes, minnows, and buffalos were slightly more common and abundant in 1978, whereas darters and saugers were more prevalent in 1980. A few mooneyes (*Hiodon tergisus*), blue catfish (*Ictalurus furcatus*), channel catfish (*I. punctatus*), black basses (*Micropterus* spp.), and a gar (*Lepisosteus* sp.) were caught in 1978, but these taxa were not represented in the present study. Blue sucker (*Cycleptus elongatus*, Table 3) larvae constituted the only addition to the known ichthyoplankton composition of the study area through 1980 sampling. Grass carp, speckled chubs, silver chubs, silverband shiners, bullhead

minnows, warmouths, orangespotted sunfish, and bluegills were all represented in 1978 collections but were reported as members of various unidentified groups. The inland silverside was reported for 1978 (Schramm and Pennington 1981) as "Mississippi silverside" (*Menidia audens*; see Robbins et al. 1980).

26. Ichthyoplankton catches from the study area--considering the present investigation as well as that of Schramm and Pennington (1981)--were qualitatively similar to those reported from near St. Francisville, La., about 354 km downstream (Conner 1976, Conner and Bryan 1976, Gallagher and Conner 1980). Since the published information from the St. Francisville area was based on a slightly different gear (towed 1-m-diam nets) used in different years (1974-1977), the similar findings in two widely separated Lower Mississippi River reaches are noteworthy and suggest that our findings are representative of the Lower Mississippi River mainstem upstream of Baton Rouge, La.

Habitat Comparisons

27. Whereas shads and herring were relatively abundant and common in all locations, other prominent taxa as well as some of the rarer forms exhibited clear affinities for certain habitats (or groups of habitats). For example, 95 percent of all sunfish larvae were taken in the abandoned channel (Matthews Bend; 82 percent on 20 August 1980). Qualitative differences and similarities among the locations are readily apparent when the taxonomic groups are listed in descending order of their relative abundances (Table 5). As might be expected on the basis of its physical relationship to the other locations, Matthews Bend was the most distinctive of the areas sampled. Its ichthyoplankton community consisted essentially of shads and sunfishes (99 percent), and lacked fishes that tended to be abundant in all of the other habitats.

28. In the other six locations, drum and carpsuckers consistently ranked second and third, respectively, and contributed (cumulatively) 33 to 42 percent of the total catches. Beyond this basic similarity, the ichthyoplankton communities of the main-river habitats were divisible

into two general groups: (a) those characterized by high relative abundances of minnows and (b) those in which minnows were less prominent. The former group was typical of habitats in or immediately adjacent to the navigation channel (i.e., the main channel and revetted bank locations) and the latter occurred in the temporary secondary channel (Kentucky Bend Bar Chute) and the two dike fields.

29. In terms of the gross taxonomic groups recognized in this study, the most diverse ichthyoplankton communities were those of the main channel, Walnut Point Revetment, and the Lower Cracraft Dike Field. Matthews Bend and the Carolina Revetment yielded the fewest kinds of larvae. However, the low diversity was probably meaningful only in the case of the abandoned channel habitat, where the missing kinds included forms that were relatively abundant and common elsewhere (e.g., grass carp and carpsuckers).

30. The abandoned channel was further distinguished from all other locations by an extremely high overall catch per effort of total ichthyoplankton (Table 6). This high relative abundance reflected concentrations of shad on 16 and 30 May and of sunfishes (virtually all bluegill) in late summer and early September (Table 7). Silversides were the only other fishes that exhibited a relative affinity for Matthews Bend.

31. Although roughly comparable, total ichthyoplankton catches in the six main-stem locations reflect apparent spawning of: (a) shads in mid-May; (b) shads and drum in late May; and (c) drum and carpsuckers in June and July (Tables 8-13). Thus, the temporary secondary channel and Walnut Point Revetment, which retained comparatively high shad concentrations through early July (Tables 10 and 13), exhibited the greatest overall ichthyoplankton abundances among main-river locations (Table 6). The Carolina Revetment (Table 9), on the other hand, yielded relatively low numbers of shads, drum, and carpsuckers, and therefore ranked last in overall catch per effort. Except on 12 June, the spring and early summer pattern of total ichthyoplankton catches in the Leota Dike Field was very similar to that of Carolina Revetment (Tables 6, 9, and 12). Indeed, it seems likely that the Leota Dike Field would have ranked much lower in overall abundance if it, like the other main-stem locations,

had been accessible for sampling during all of the late summer and early autumn.

32. After July, the main-stem habitat ichthyoplankton catches tended to follow two basic patterns (Tables 8-13). Main-channel and revetted bank stations were essentially populated by drum, minnows, and carpsuckers, and exhibited more or less steady declines in overall abundance until 2 October, the last time when larvae were caught during the habitat comparison phase of sampling (Tables 8-10). The second pattern was characteristic of the temporary secondary channel and dike field locations and involved slight abundance pulses of sunfishes, shad, and, in one case, silversides (Table 11). Drum, minnows, and carpsuckers were generally sparse in the late summer/early autumn samples from these isolated or semi-isolated habitats.

33. There were qualitative and quantitative differences between the abandoned channel (Matthews Bend) and the six main-stem locations. While most of the more common and abundant kinds of fish larvae occurred in all main-stem habitats at least at times (i.e., during high to moderate river stages), certain major taxonomic groups were either absent from or extremely rare in Matthews Bend (e.g., grass carp, minnows, carpsuckers, drum). In terms of overall catches per effort of ichthyoplankton, the abandoned channel was distinctly more productive than the main-stem habitats; however, this was a reflection of relatively ephemeral peaks in abundance of shads and sunfishes. At times other than these apparent spawning peaks, the main-stem locations yielded roughly equal or even greater catches of larvae than the abandoned channel.

34. Less pronounced trends indicated a basic dichotomy among the six main-stem locations. One group consisted of the habitats in, or immediately adjacent to, the navigation channel (main channel and revetted bank locations). The other group included those habitats that are less intimately associated, especially at low river stages, with the permanent channel (dike field and Kentucky Bend Bar Chute stations). These groups will be referred to, respectively, as main-channel and off-channel habitats. It was during the period of lower river stages--generally the latter half of the summer and early autumn--that the principal

differences among off-channel habitats were seen. During high and moderate river stages, shad dominated the catches at all off-channel stations (as they did in Matthews Bend). But from late June/early July onward, drum, carpsuckers, and minnows prevailed in main-channel locations, while sunfishes and shad dominated catches in off-channel habitats. In this last respect the off-channel locations somewhat resembled the abandoned channel. Thus, the array of habitats compared in this study reflected a continuum whose extremes were the main channel (including revetted bank habitats) and the abandoned channel (Figure 4).

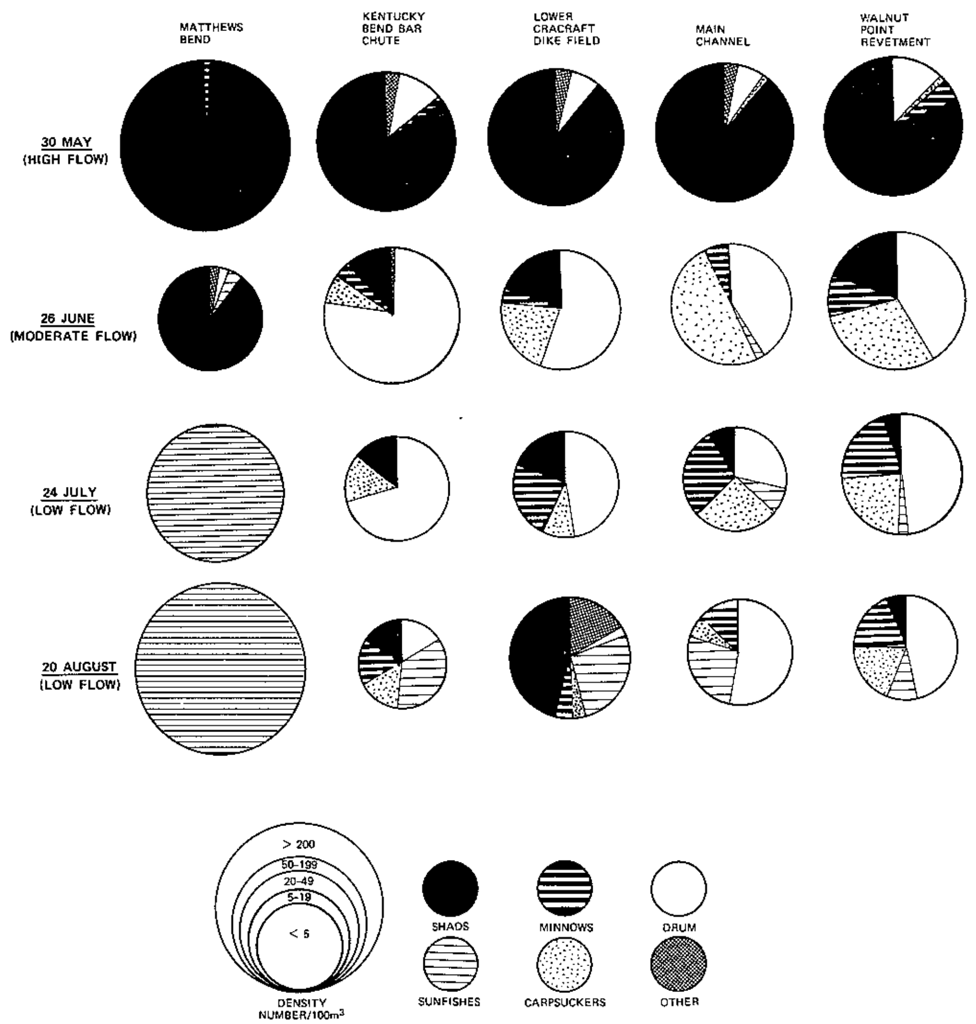

Figure 4. Relative abundance of major groups of larval fish from five habitats at different river flow stages

Dike Field Distribution

35. The Lower Cracraft Dike Field displayed spatial and temporal variability in the diversity and abundance of larval fishes (Tables 11 and 14). Collections from April through June reflected high river stage conditions. On 17 April the samples contained a fairly high diversity of taxa dominated by shad and buffalo. There was a pronounced tendency for abundance estimates to be higher at stations away from the shore (open water) than at those nearshore. Diversity was again fairly high on 16 May, but with a preponderance of shad (ca. 83 percent overall). As in April, the abundance tended to be higher in the open water than nearshore. The highest overall catches per effort among dike field sampling visits occurred on 12 June. The high diversity on this date reflected the presence of both late-spring-spawner larval concentrations and some summer-spawning species (i.e., minnows, carpsucker, and drum). The collections were dominated by shad (mainly *D. cepedianum*) and drum in roughly equal proportions. In general, collections were roughly comparable at open-water versus nearshore stations. However, there was a tendency for shad to dominate nearshore while drum dominated in open water.

36. Collections from July through October reflect moderate to low river stages. From 10 July through 4 September diversity was fairly low (Figures 5-9 and Table 11), as indeed it was in all major habitats--the low water or summer ichthyoplankton community having become established. The greatest concentrations in the dike field tended to be inside the middle bar, particularly at shoreline stations rather than in the open water. The fishes comprising these inside concentrations were mainly shad, bluegills, and silversides (*Menidia* spp.), whereas those along the riverside of the middle bar were mainly minnows (especially speckled chubs and some *Notropis* spp.), carpsuckers, and drum.

37. From 17 September onward, larval fish were very sparse in general and were virtually absent from the interior dike field stations (Figure 10 and Tables 11 and 14).

38. The foregoing is rather noteworthy in the context of the

habitat comparison phase of the study. Clearly, under low water conditions the dike field ichthyoplankton community is in fact two communities. The community of the interior is unusual, being dominated by sunfish, silversides (ephemerally), and shad, whereas the abandoned channel (the habitat which it most closely resembles) had essentially only sunfish during low water. The community along the riverside of the middle bar is not substantially different from that of the main channel or from the sandbar community noted by Schramm and Pennington (1981). Thus, if only the interior stations had been used to represent the Lower Cracraft Dike Field, the dike field would have been interpreted as a habitat with a more distinctive fauna.

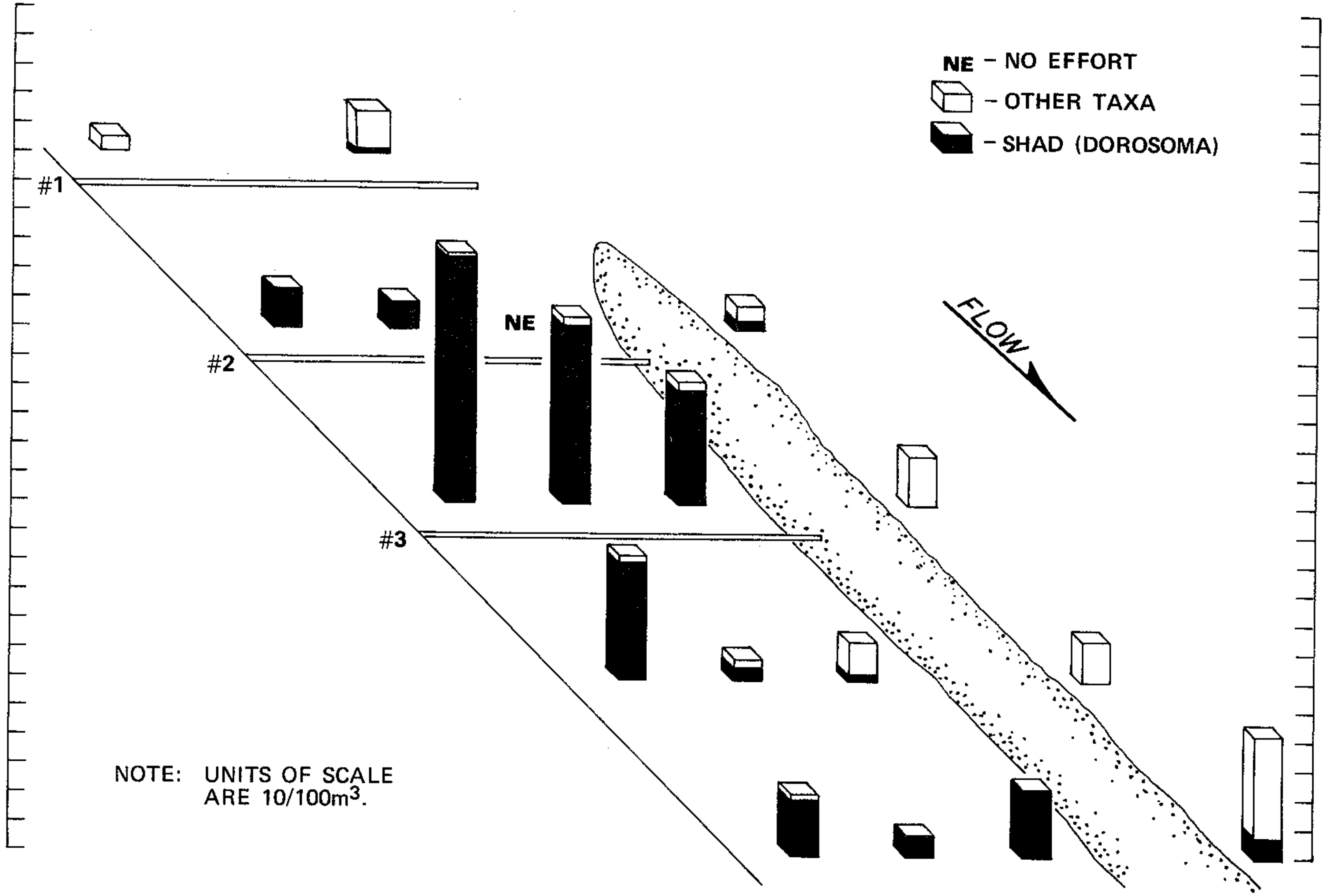

Figure 5. Catch per unit of effort (No./100m^3) of larval fish in the Lower Cracraft Dike Field, Lower Mississippi River, on 10 July 1980

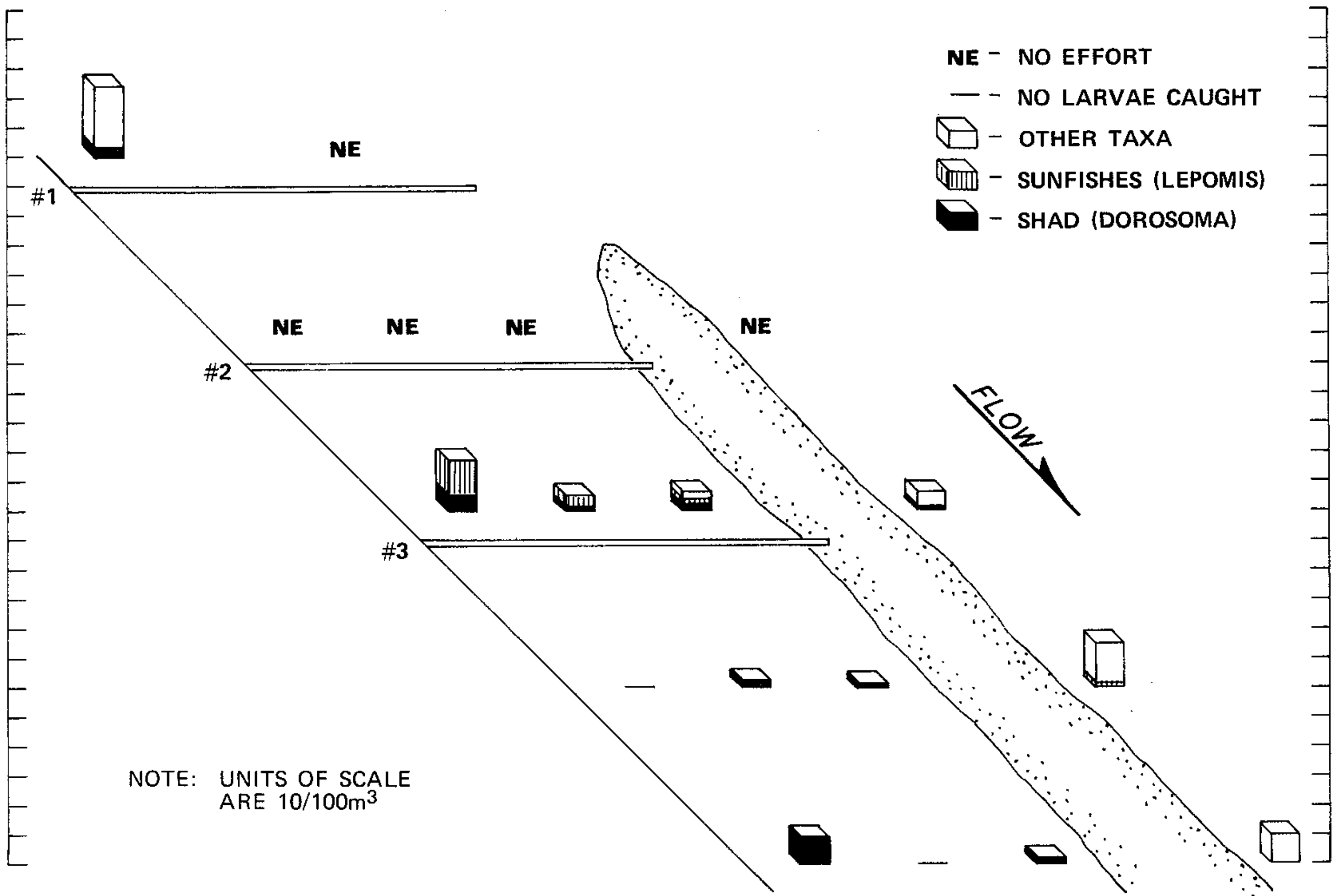

Figure 6. Catch per unit of effort (No./100m^3) of larval fish in the Lower Cracraft Dike Field, Lower Mississippi, River, on 24 July 1980

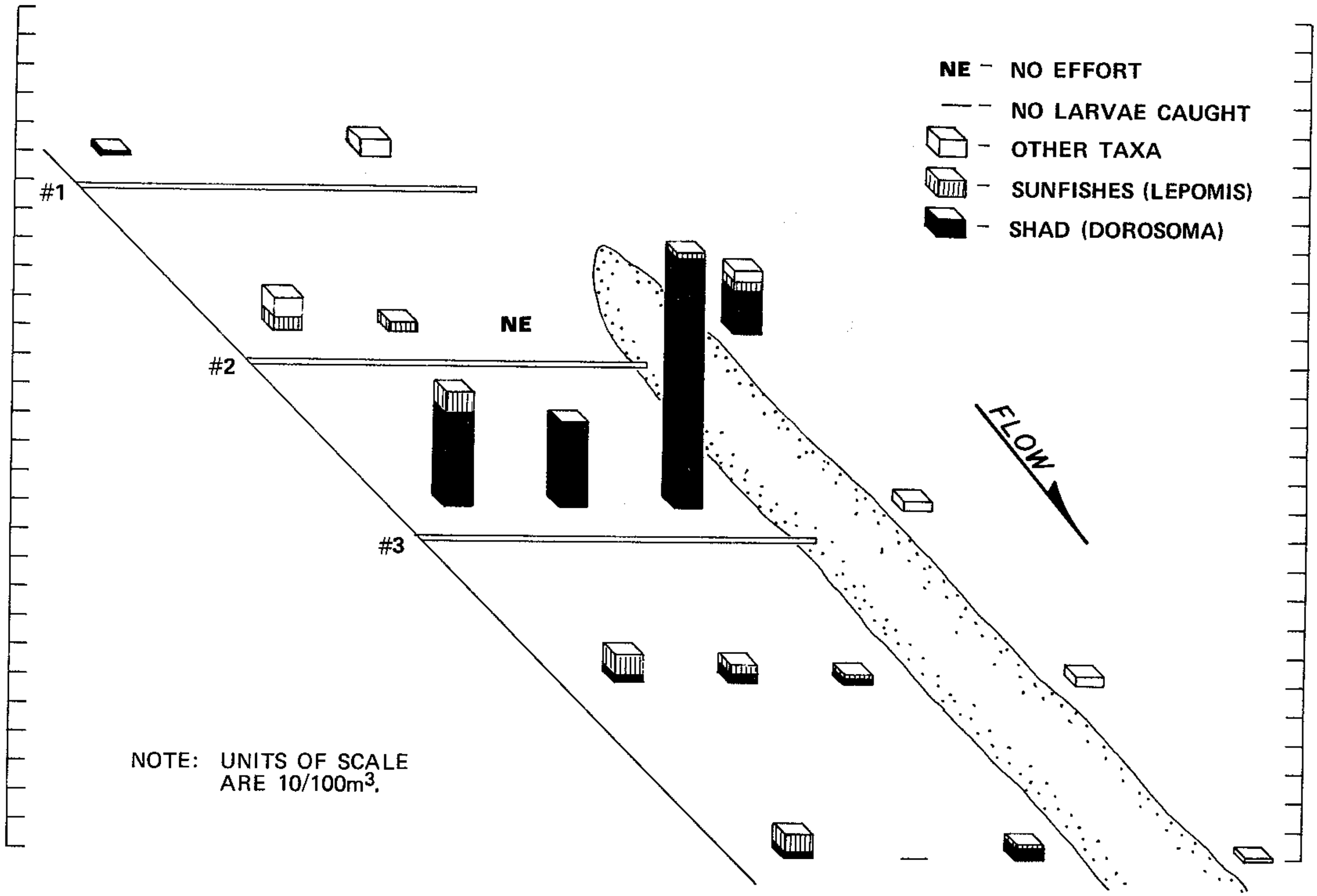

Figure 7. Catch per unit of effort (No./100m^3) of larval fish in the Lower Cracraft Dike Field, Lower Mississippi River, on 8 August 1980

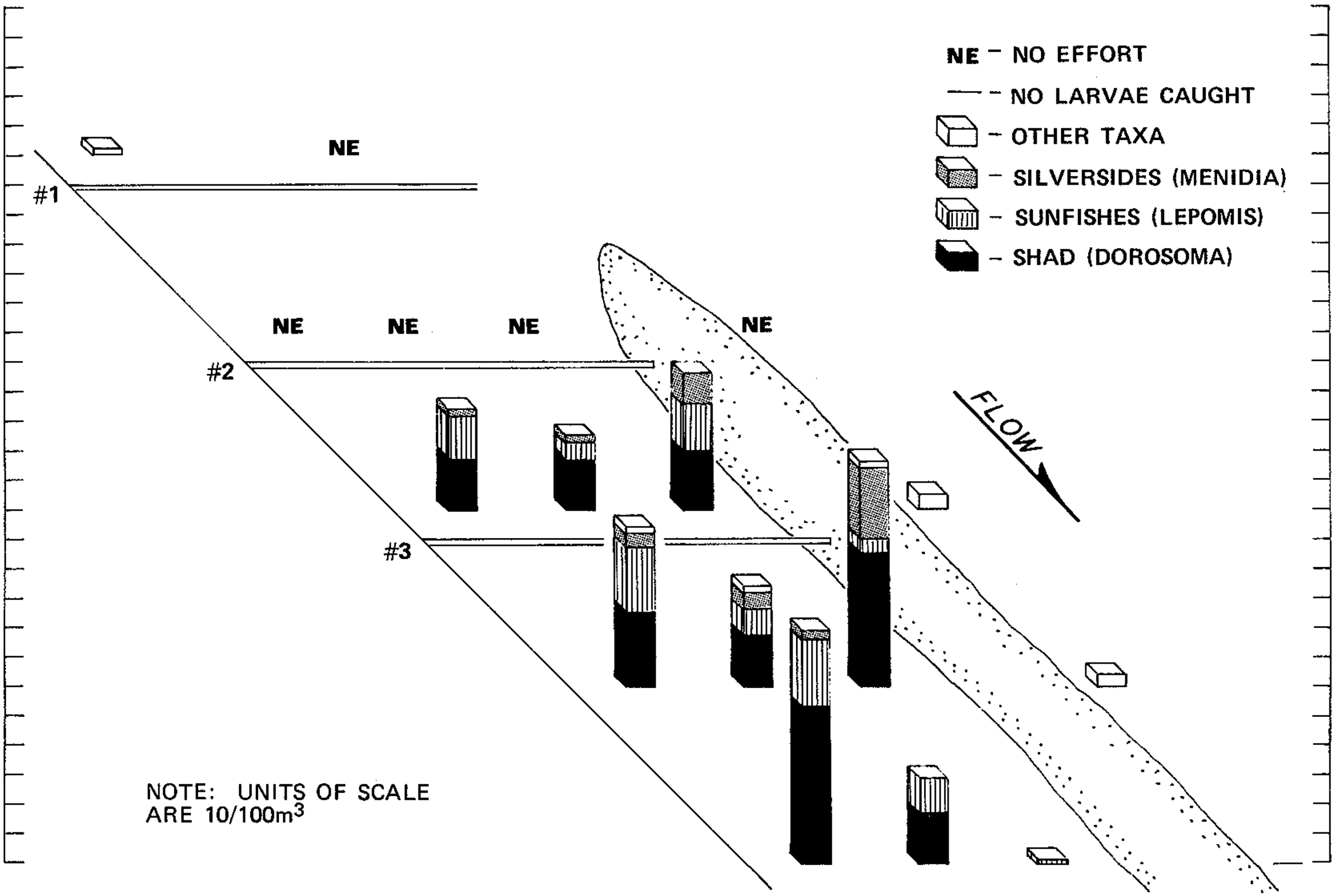

Figure 8. Catch per unit of effort (No./100m^3) of larval fish in the Lower Cracraft Dike Field, Lower Mississippi River, on 20 August 1980

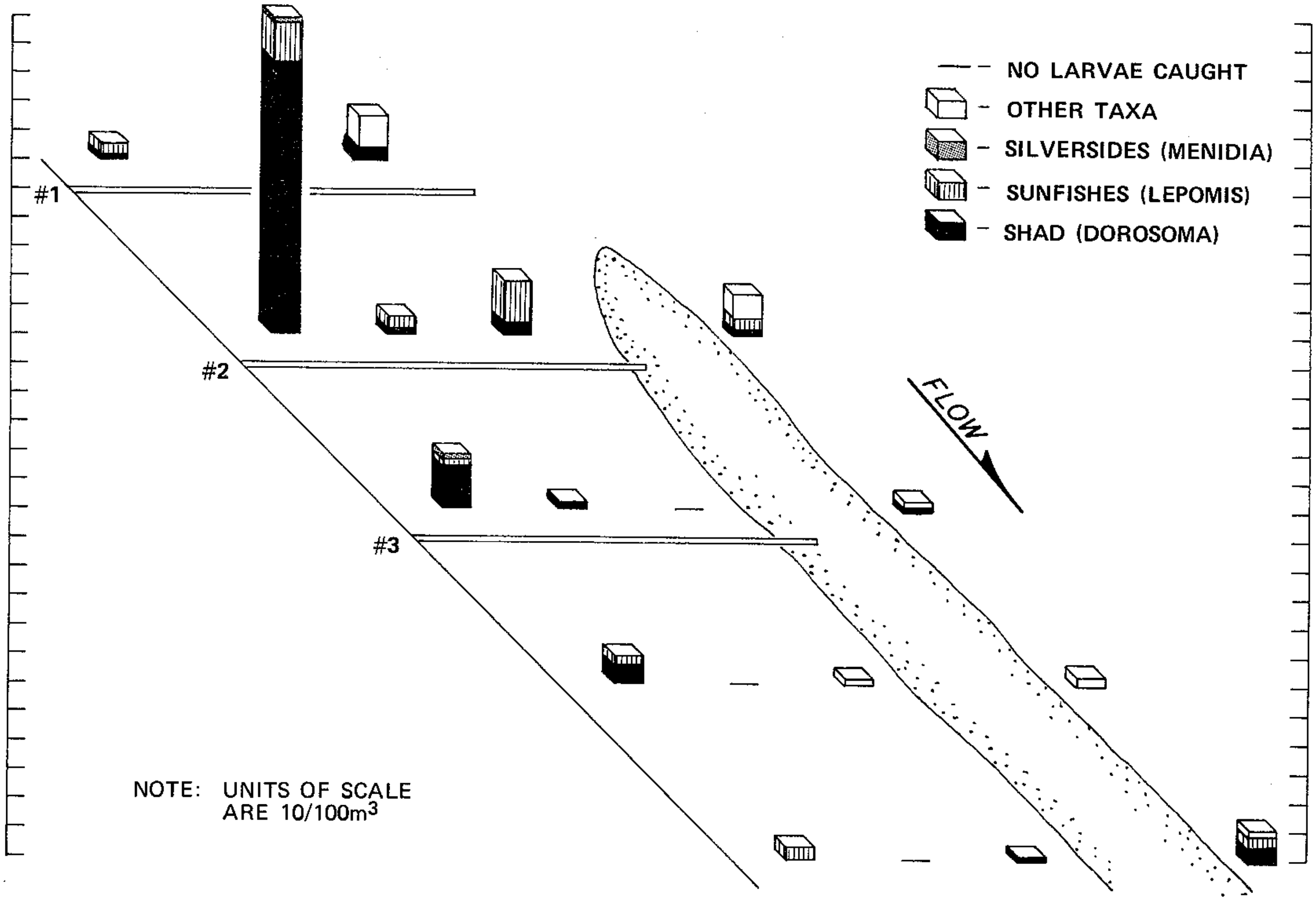

Figure 9. Catch per unit of effort (No./100m^3) of larval fish in the Lower Cracraft Dike Field, Lower Mississippi River, on 4 September 1980

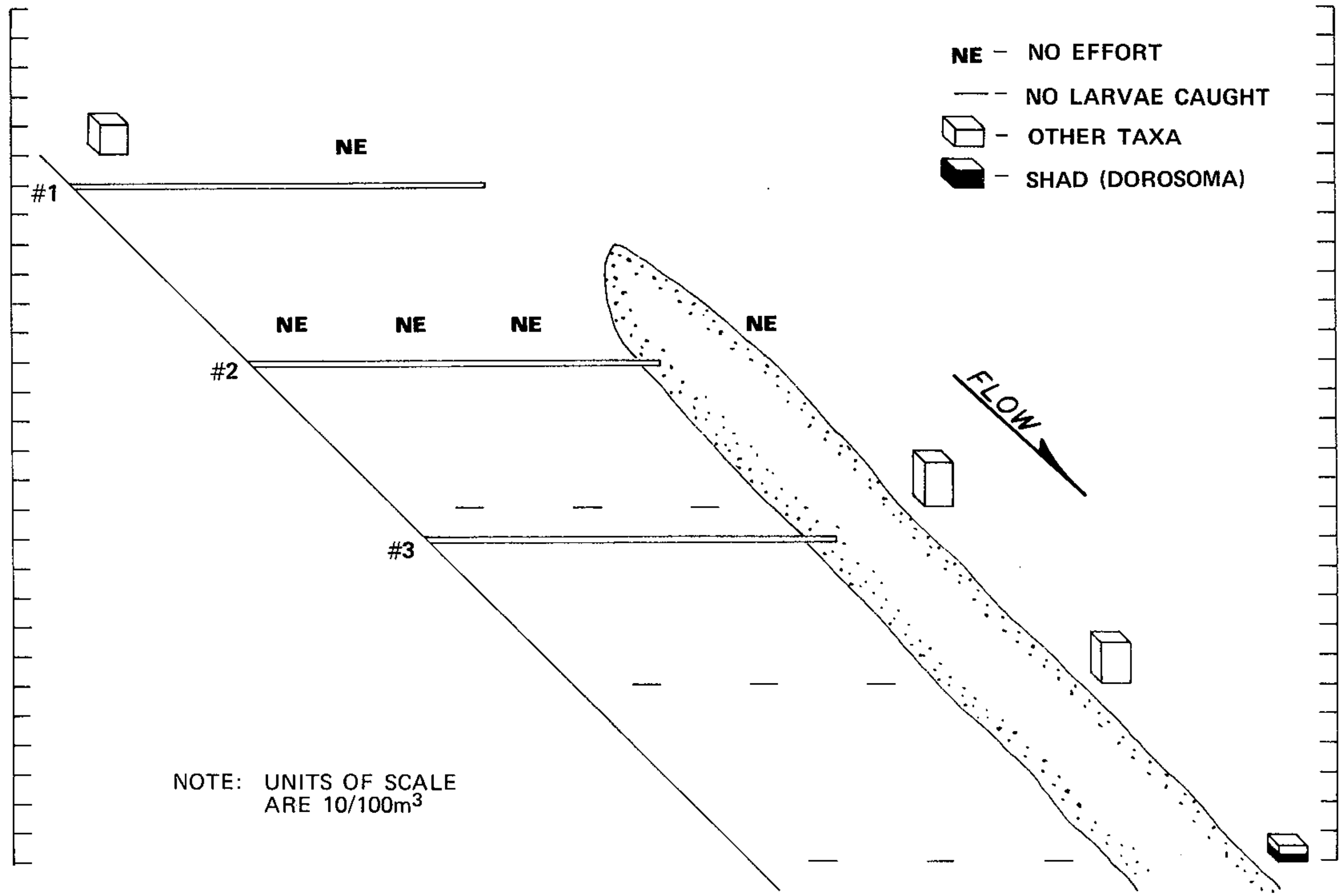

Figure 10. Catch per unit of effort (No./100m^3) of larval fish in the Lower Cracraft Dike Field, Lower Mississippi, on 17 September 1980

PART IV: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

39. Ichthyoplankton collections from this study area were qualitatively similar to those reported from near St. Francisville, La. With respect to planktonic larval fish ecology, the results of this study in the Lake Providence, La., to Greenville, Miss., reach may be fairly representative of the Lower Mississippi River main stem north of Baton Rouge, La.

40. Shads and herring were relatively abundant and common in all locations, while other prominent taxa as well as some of the larger forms exhibited clear affinities for certain habitats (or groups of habitats). Matthews Bend (an abandoned channel) had the most distinctive fauna. Its ichthyoplankton community consisted essentially of shads and sunfishes and lacked fishes that tended to rank highly in all other habitats.

41. The ichthyoplankton of the abandoned channel was more abundant than in main-stem habitats, although this was a reflection of relatively ephemeral peaks in abundance of shads and sunfishes. At times other than these apparent spawning peaks, the main-stem habitats yielded equal or higher catches of larvae than the abandoned channel.

42. Mainly qualitative trends indicated a basic dichotomy among the six main-stem locations. One group (main-channel habitats) consisted of habitats in, or immediately adjacent to, the navigation channel (main channel and revetted bank locations). The other group (off-channel habitats) included those habitats that are less intimately associated, especially at low river stages, with the navigation channel (dike field and Kentucky Bend Bar Chute locations). During high and moderate river stages, shad dominated the collections at all main-stem stations, as they did at Matthews Bend. However, during the lower river stages (latter half of the summer and early autumn), there were differences among main-stem habitats. Drum, carpsuckers, and minnows dominated in main-channel habitats, while sunfishes and shad prevailed in

collections from off-channel habitats. Overall, the array of habitats compared in this study reflected a continuum whose extremes were the main channel and the abandoned channel.

43. The Lower Cracraft Dike Field had spatial and temporal variability in larval fish diversity and abundance throughout the spawning season. Collections from April through June reflected high to moderate river stage conditions. During this period larval fish diversity was high and abundance was greater at open water stations than nearshore stations. Collections from July through October reflected moderate to low river stages. At this time, diversity of larval fishes was fairly low, as it was in all major habitats. Under low water conditions the dike field ichthyoplankton community is actually two communities with the greatest abundance tending to be inside the middle bar, especially along the shoreline rather than in the open pool. Fishes comprising this inside community were mainly shads, bluegill, and silversides. The community along the riverside of the middle bar is not substantially different from that of the main channel.

Recommendations

44. Because of the apparent importance of abandoned channels as habitat for larvae of forage and sport fishes, these and other off-channel habitats should be maintained and left undisturbed during construction and maintenance of channel alignment structures.

45. Placement of dikes and revetments should not coincide with the peak spawning season, May through July for the majority of the warmwater fishes. If possible, construction activities should be delayed as late as possible (September-October).

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Table 1

Distribution of Effort* During Habitat Comparison Sampling of Ichthyoplankton in 1980

Habitat	High River Stages						Moderate to Low River Stages							
	17 Apr	1 May	16 May	30 May	12 Jun	26 Jun	10 Jul	24 Jul	8 Aug	20 Aug	4 Sep	17 Sep	2 Oct	16 Oct
Main Channel	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Carolina Revetment	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Walnut Point Revetment	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Lower Cracraft Dike Field	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Leota Dike Field	XX	XX	X	XX	XX	XX	X				X**			
Kentucky Bend Bar Chute	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	X	X	X
Matthews Bend	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX

* X's denote number of stations representing habitat on date in question; two trials (net pushes) made at each station.

** Station visited on 10 September.

Table 2

Sampling Frequency* in Study of Ichthyoplankton Distribution in Lower Cracraft Dike Field, 1980

Stations	High River Stages			Moderate to Low River Stages							
	17 Apr	16 May	12 Jun	10 Jul	24 Jul	8 Aug	20 Aug	4 Sep	17 Sep	2 Oct	16 Oct
Above First Dike											
Nearshore	X	X	X	X	X	X	X	X	X	X	X
Offshore	XX	XX	XX	XX		XX		XX		XX	
Below First Dike											
Nearshore	X	X	X	X		X		X		X	
Offshore	XXX	XX	XXX								
Midpool				X				X			
Poolside of Bar								X			
Riverside of Bar				X		X		X		X	
Below Second Dike											
Nearshore	X	X	X	X	X	X	X	X	X	X	X
Offshore	XXX	XXX	XX								
Midpool				X	X	X	X	X	X	X	X
Poolside of Bar				X	X	X	X	X	X	X	X
Riverside of Bar				X	X	X	X	X	X	X	X
Below Third Dike											
Upper Nearshore	X	X	X	X	X	X	X	X	X	X	
Upper Offshore	XXX	XXX	XXX								
Upper Midpool				X	X	X	X	X	X	X	
Upper Poolside of Bar				X	X	X	X	X	X	X	
Upper Riverside of Bar				X	X	X	X	X	X	X	
Lower Nearshore	X	X	X	X	X	X	X	X	X	X	X
Lower Offshore	XXX	XXX	XXX								
Lower Midpool				X	X	X	X	X	X	X	X
Lower Poolside of Bar				X	X	X	X	X	X	X	X
Lower Riverside of Bar				X	X	X	X	X	X	X	X
Along Dikes											
Downstream Second Dike		X		X	X	X	X	X	X	X	X
Upstream Third Dike		X		X	X	X	X	X	X	X	X
Downstream Third Dike		X		X	X	X	X	X	X	X	

* X's denote number of stations representing habitat on date in question; two trials (net pushes) made at each station.

Table 3

Composition of Taxonomic Groups or "Kinds" of Larval Fish Collected in the Lower Mississippi River, 17 April Through 16 October 1980

SHADS AND HERRING (Family Clupeidae)

Alosa chrysochloris (Rafinesque) - skipjack herring
Dorosoma cepedianum (Lesueur) - gizzard shad
D. petenense (Gunther) - threadfin shad*

GOLDEYE (Family Hiodontidae)

Hiodon alosoides (Rafinesque) - goldeye

GRASS CARP (Family Cyprinidae)

Ctenopharyngodon idella (Valenciennes) - grass carp

COMMON CARP (Family Cyprinidae)

Cyprinus carpio Linnaeus - common carp

MINNOWS (Family Cyprinidae)

Hybopsis aestivalis (Girard) - speckled chub*
H. storeriana (Kirtland) - silver chub
Hybopsis spp. - speckled and/or silver chubs
Notropis atherinoides Rafinesque - emerald shiner
N. shumardi (Girard) - silverband shiner
Notropis spp. - 2 or 3 unidentified shiners
Pimephales vigilax (Baird and Girard) - bullhead minnow

CARPSUCKERS (Family Catostomidae)

Carpiodes carpio (Rafinesque) - river carpsucker*
C. cyprinus (Lesueur) - quillback**
Carpiodes spp. - river and/or quillback carpsuckers

BUFFALOS (Family Catostomidae)

Ictiobus bubalus (Rafinesque) - smallmouth buffalo
I. cyprinellus (Valenciennes) - bigmouth buffalo
I. niger (Rafinesque) - black buffalo**
Ictiobus spp. - smallmouth, bigmouth, and/or black buffalos

(Continued)

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* Clearly preponderant member of a group.
** Occurrence unconfirmed, but possible in light of adult distribution.

Table 3 (Concluded)

"OTHER" SUCKERS (Family Catostomidae)

Cycleptus elongatus (Lesueur) - blue sucker
Immature/damaged carpsuckers or buffalos (genus indistinguishable)

SILVERSIDES (Family Atherinidae)

Labidesthes sicculus (Cope) - brook silverside
Menidia beryllina (Cope) - inland silverside*
Immature/damaged silversides (genus indistinguishable)

TEMPERATE BASSES (Family Percichthyidae)

Morone chrysops (Rafinesque) - white bass*
M. Mississippiensis Jordan and Eigenmann - yellow bass**

SUNFISHES (Family Centrarchidae)

Lepomis gulosus (Cuvier) - warmouth
L. humilis (Girard) - orangespotted sunfish
L. macrochirus Rafinesque - bluegill*
Lepomis spp. - 1 or 2 unidentified sunfishes

CRAPPIES (Family Centrarchidae)

Pomoxis annularis Rafinesque - white crappie*
P. nigromaculatus (Lesueur) - black crappie
Pomoxis spp. - white and/or black crappies

DARTERS (Family Percidae)

Etheostoma spp. - 2 or 3 unidentified darters

SAUGER (Family Percidae)

Stizostedion canadense (Smith) - sauger

DRUM (Family Sciaenidae)

Aplodinotus grunniens Rafinesque - freshwater drum

DAMAGED FISH

Fragments/damaged specimens (family indistinguishable)

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* Clearly preponderant member of a group.
** Occurrence unconfirmed, but possible in light of adult distribution.

Table 4

Overall Relative Abundance and Occurrence of Larval Fish Collected During Habitat Comparison Sampling in the Lower Mississippi River, 17 April Through 16 October 1980

Group or "Kind"	Total Specimens	Catch/Effort (No./100 m^3)	Percent of All Larvae	Frequency of Occurrence	Temporal Occurrence*	Abundance Peak(s)*
Shads/Herring	5,461	34.11	54.45	63.13	m-Apr to e-Oct	m and ℓ May
Sunfishes	2,202	13.76	21.96	27.37	m-Apr to e-Oct	ℓ-Jul and ℓ-Aug
Drum	1,549	9.68	15.45	51.95	e-May to e-Oct	e-Jun to e-Jul
Carpsuckers	332	2.07	3.30	35.75	m-May to m-Sep	ℓ-Jun
Minnows	135	0.84	1.34	34.64	m-Apr to m-Sep	Jul
Buffalos	94	0.59	0.94	22.91	m-Apr to m-Jun	m-Apr to m-May
Grass carp	60	0.37	0.59	12.29	m-May to m-Sep	ℓ-Jun
Temperate basses	48	0.30	0.48	18.99	m-Apr to e-Aug	e-May
Common carp	46	0.29	0.46	11.17	m-Apr to m-Jun	m-Apr to e-May
Crappies	42	0.26	0.42	14.53	m-Apr to m-Jun	e and m-May
Silversides	19	0.12	0.19	5.59	m-Apr to ℓ-Aug	m-Apr and ℓ-Aug
Sauger	9	0.06	0.10	2.23	e-May to m-May	e-May
Darters	8	0.05	0.08	2.79	m-Apr to e-May	m-Apr
Goldeye	7	0.04	0.06	2.79	m-May to ℓ-May	m-May
"Other" suckers	4	0.03	0.05	1.68		
Damaged fish	13	0.08	0.13	5.59		
	10,029	62.65	100.00			

* The symbols, e, m, and ℓ denote early, mid, and late portions of months in question.

Table 5

Ichthyoplankton Community Composition* at Seven Lower Mississipi River Locations

Sampled from 17 April Through 16 October 1980

Main Channel	Carolina Revetment	Walnut Point Revetment	Lower Cracraft Dike Field	Leota Dike Field	Kentucky Bend Bar Chute	Matthews Bend
SHADS/HERRING	SHADS/HERRING	SHADS/HERRING	SHADS/HERRING	SHADS/HERRING	SHADS/HERRING	SHADS/HERRING
DRUM	DRUM	DRUM	DRUM	DRUM	DRUM	SUNFISHES
CARPSUCKERS	CARPSUCKERS	CARPSUCKERS	CARPSUCKERS	CARPSUCKERS	CARPSUCKERS	Common carp
MINNOWS	MINNOWS	MINNOWS	SUNFISHES	BUFFALOS	SUNFISHES	Buffalos
BUFFALOS	GRASS CARP	GRASS CARP	MINNOWS	SUNFISHES	TEMP. BASSES	Silversides
Temp. basses	CRAPPIES	BUFFALOS	BUFFALOS	TEMP. BASSES	COMMON CARP	Crappies
Sunfishes	BUFFALOS	Sunfishes	Common carp	Minnows	Crappies	Temp. basses
Goldeye	Temp. basses	Temp. basses	Silversides	Grass carps	Buffalos	Minnows
Grass carp	Common carp	Common carp	Crappies	Common carp	Minnows	Drum
Common carp	Sunfishes	Crappies	Temp. basses	Crappies	Grass carp	Darters
Darters		Goldeye	Grass carp	Goldeye	Sauger	
Crappies		Silversides	Sauger		Darters	
Silversides		Sauger	Darters			

* Groups or "Kinds" of larval fish listed in descending order of overall relative abundance (No./100 m^3), with those cumulatively contributing 95 percent or more of the total catch capitalized.

Table 6

Comparative Abundance (No./100 m^3) and Diversity (No. of Kinds) of Larval Fish in Seven Lower Mississippi River Locations Sampled in 1980

Date	Main Channel	Carolina Revetment	Walnut Point Revetment	Lower Cracraft Dike Field	Leota Dike Field	Kentucky Bend Bar Chute	Matthews Bend
17 April	17.8 (8)	9.5 (4)	7.2 (5)	12.9 (7)	5.5 (2)	24.0 (6)	22.0 (7)
1 May	26.7 (5)	18.5 (6)	34.1 (7)	86.8 (10)	33.8 (4)	78.0 (7)	41.5 (2)
16 May	36.5 (6)	32.8 (6)	23.8 (7)	37.1 (7)	25.1 (7)	106.1 (5)	976.0 (3)
30 May	196.3 (7)	75.7 (9)	100.6 (11)	133.0 (9)	75.2 (6)	178.6 (10)	606.8 (4)
12 June	25.4 (4)	24.1 (5)	176.3 (8)	97.1 (7)	77.2 (7)	126.3 (7)	25.5 (2)
26 June	21.2 (4)	47.5 (5)	103.6 (5)	48.2 (5)	45.5 (4)	99.5 (6)	17.7 (4)
10 July	78.8 (4)	19.6 (4)	107.6 (6)	6.2 (3)	26.7 (5)	43.4 (4)	1.4 (3)
24 July	5.9 (5)	5.9 (5)	28.4 (5)	11.1 (4)	NE	8.4 (3)	98.7 (2)
8 August	11.7 (3)	8.9 (2)	16.5 (5)	3.7 (2)	NE	1.0 (2)	2.3 (3)
20 August	7.6 (5)	3.8 (3)	12.0 (6)	19.5 (6)	NE	3.2 (5)	777.8 (2)
4 September	4.2 (2)	4.8 (4)	5.4 (4)	2.5 (2)	7.3 (2)*	6.0 (3)	32.2 (2)
17 September	4.8 (3)	2.9 (2)	5.4 (3)	5.6 (1)	NE	1.0 (1)	5.5 (1)
2 October	0.6 (1)	--	0.5 (1)	--	NE	--	1.1 (1)
16 October	--	--	--	--	NE	--	--
Overall No./100 m^3	32.0	18.9	46.8	33.1	42.5	53.1	187.8
Total Effort (m^3)	2631	2260	2433	2551	1131	2300	2702

Note: Number in parentheses is number of major taxa or "kinds" as outlined in Table 3.
* Sample taken on 10 September.

Table 7

Relative Abundance (No./100 m^3) of Larval Fish at Matthews Bend Stations in the Lower Mississippi River, 1980

	High River Stages						Moderate to Low River Stages							
Larval Fish	17 Apr	1 May	16 May	30 May	12 Jun	26 Jun	10 Jul	24 Jul	8 Aug	20 Aug	4 Sep	17 Sep	2 Oct	16 Oct
Shads/Herring	3.7	40.8	974.8	597.5	24.5	15.9		0.5			4.9			
Common carp	6.1													
Minnows				0.5			0.5							
Buffalos	5.5													
Silversides	2.4		0.6			0.5	0.5		0.9					
Temp. basses	1.2								0.5					
Sunfishes				8.3	1.0	0.9	0.5	98.2	0.9	777.4	27.3	5.5	1.1	
Crappies	2.4	0.7	0.6	0.5										
Darters	0.6													
Drum						0.5				0.4				
Total larvae	22.0	41.5	976.0	606.8	25.5	17.7	1.4	98.7	2.3	777.8	32.2	5.5	1.1	--
Effort (m^3)	164	145	163	193	208	221	209	199	213	238	183	199	176	192

Table 8

Relative Abundance (No./100 m^3) of Larval Fish at Main-Channel Stations in the Lower Mississippi River, 1980

	High River Stages						Moderate to Low River Stages							
Larval Fish	17 Apr	1 May	16 May	30 May	12 Jun	26 Jun	10 Jul	24 Jul	8 Aug	20 Aug	4 Sep	17 Sep	2 Oct	16 Oct
Shads/Herring	9.7	20.6	23.3	174.6	3.9		1.3	0.5						
Goldeye			1.1	1.1										
Grass carp						1.4						0.6		
Common carp	0.5	2.1												
Minnows	1.1		1.6				0.9	1.6	0.5	1.0		0.6		
Carpsuckers			0.5	2.2	1.5	10.6	2.7	1.6	3.9	0.5				
Buffalos	2.7	1.4	2.1	1.1										
Silversides										0.5				
Temp. basses	0.5	1.4		1.6	0.5									
Sunfishes						0.5		0.5		1.4	1.6			
Crappies	0.5	1.4												
Darters	2.2													
Drum			7.9	13.6	19.5	8.7	73.9	1.6	7.3	4.3	3.6	3.6	0.6	
Damaged fish	0.5			2.2										
Total larvae	17.7	26.9	36.5	196.3	25.4	21.2	78.8	5.9	11.7	7.6	5.2	4.8	0.6	--
Effort (m^3)	185	146	189	184	205	207	223	187	205	211	165	167	174	183

Table 9

Relative Abundance (No./100 m^3) of Larval Fish at Carolina Revetment Stations in the Lower Mississippi River, 1980

Larval Fish	High River Stages						Moderate to Low River Stages							
	17 Apr	1 May	16 May	30 May	12 Jun	26 Jun	10 Jul	24 Jul	8 Aug	20 Aug	4 Sep	17 Sep	2 Oct	16 Oct
Shads/Herring	4.8	11.6	17.2	62.8	8.2	3.1	2.2	0.6			0.7			
Grass carp				1.2	1.1	3.1								
Common carp		1.5		0.6										
Minnows			2.7	1.2	1.6	2.5	2.8	2.4		1.3	2.8	1.7		
Carpsuckers				1.2	2.2	15.0	1.1	0.6	1.0	1.3				
Buffalos	3.0	0.8	1.1											
Temp. basses	1.2		1.1	0.6										
Sunfishes				0.6				0.6			0.7			
Crappies	0.6	3.1	2.1											
Drum		0.8	8.6	7.0	11.0	23.8	13.4	1.8	7.8	1.3		1.1		
Damaged fish		0.8		0.6							0.7			
Total larvae	9.5	18.5	32.8	75.7	24.1	47.5	19.6	5.9	8.9	3.8	4.8	2.9	--	--
Effort (m^3)	168	130	186	170	183	160	179	169	192	156	145	174	153	96

Table 10

Relative Abundance (No./100 m^3) of Larval Fish at Walnut Point Revetment Stations in the Lower Mississippi River, 1980

	High River Stages						Moderate to Low River Stages							
Larval Fish	17 Apr	1 May	16 May	30 May	12 Jun	26 Jun	10 Jul	24 Jul	8 Aug	20 Aug	4 Sep	17 Sep	2 Oct	16 Oct
Shads/Herring	3.9	23.2	12.4	77.7	132.9	19.8	21.0	1.3	1.1	0.6	1.4		0.5	
Goldeye			1.1											
Grass carp				1.2	0.5	13.4						1.4		
Common carp	0.6	0.7		0.6										
Minnows		0.7	1.7	3.5	1.1	2.5	4.9	6.0	4.8	2.3	2.7	1.4		
Carpsuckers				1.2	3.3	24.3	12.7	6.6	2.7	2.3	0.7			
Buffalos	1.1	6.1	5.1	1.2	0.5									
"Other" suckers	0.6		0.6											
Silversides				0.6						0.6				
Temp. basses	1.1	1.4		0.6			0.5							
Sunfishes				0.6	0.5		0.5	0.7	0.5	1.1	0.7			
Crappies		1.4			0.5									
Sauger			0.6											
Drum		0.7	2.3	12.9	36.8	43.6	67.5	13.9	7.5	5.1		2.7		
Damaged fish				0.6										
Total larvae	7.2	34.1	23.8	100.6	176.1	103.6	107.2	28.4	16.5	12.0	5.4	5.4	0.5	--
Effort (m^3)	180	147	177	170	182	202	204	151	188	175	147	148	184	177

Table 11

Relative Abundance (No./100 m^3) of Larval Fish at Selected* Lower Cracraft Dike Field Stations in the Lower Mississippi River, 1980

Larval Fish	High River Stages						Moderate to Low River Stages							
	17 Apr	1 May	16 May	30 May	12 Jun	26 Jun	10 Jul	24 Jul	8 Aug	20 Aug	4 Sep	17 Sep	2 Oct	16 Oct
Shads/Herring	6.5	67.3	31.2	117.9	23.6	9.1	1.9	2.1	1.9	8.9	0.5			
Grass carp				0.5		0.4								
Common carp	1.2	5.8												
Minnows		0.7	1.2	0.5	0.5	1.7		2.6		1.1				
Carpsuckers			0.6	0.5	2.6	10.0	3.3	1.1		0.5				
Buffalos	1.8	3.6	0.6	1.1	1.0									
"Other" suckers	1.2													
Silversides				0.5						3.2				
Temp. basses	0.6	1.4			1.0									
Sunfishes	0.6	3.6	1.8	1.1	0.5				1.9	5.3	2.0			
Crappies	1.2	0.7	1.2	0.5										
Darters		0.7												
Sauger		1.4												
Drum		1.4		10.3	67.7	27.0	1.0	5.3		0.5		5.6		
Damaged fish			0.6											
Total larvae	13.1	86.6	37.1	133.0	96.9	48.2	6.2	11.1	3.7	19.5	2.5	5.6	--	--
Effort (m^3)	171	138	167	185	191	241	209	190	214	190	202	178	171	106

* For habitat comparison study only; more detailed information for some sampling dates is included in Table 14.

Table 12

Relative Abundance (No./100 m^3) of Larval Fish at Leota Dike Field Stations in the Lower Mississippi River, 1980

	High River Stages						Moderate to Low River Stages	
Larval Fish	17 Apr	1 May	16 May	30 May	12 Jun	26 Jun	10 Jul	10 Sep
Shads/Herring	2.0	28.1	11.3	57.8	42.1	4.2	1.8	1.2
Goldeye			1.3					
Grass carp						1.9		
Common carp		2.2						
Minnows			1.3		2.0		1.8	
Carpsuckers			2.5	3.7	8.1	19.7	3.6	
Buffalos	3.4	2.9	5.0	1.9	0.5			
Temp. basses		0.7	2.5	1.2	1.5			
Sunfishes					1.5		0.9	6.1
Crappies				1.2				
Drum				9.3	21.3	19.7	18.7	
Damaged fish			1.3					
Total larvae	5.5	3.8	25.1	75.2	77.2	45.5	26.7	7.3
Effort (m^3)	147	139	80	161	197	213	113	82

Table 13

Relative Abundance (No./100 m^3) of Larval Fish at Kentucky Bend Bar Chute Stations in the Lower Mississippi River, 1980

	High River Stages						Moderate to Low River Stages							
Larval Fish	17 Apr	1 May	16 May	30 May	12 Jun	26 Jun	10 Jul	24 Jul	8 Aug	20 Aug	4 Sep	17 Sep	2 Oct	16 Oct
Shads/Herring	16.6	58.5	93.2	150.5	64.4	11.0	12.5	1.2		0.5	3.3	1.0		
Grass carp				1.1		3.3								
Common carp	1.8	4.9		1.1	0.5									
Minnows	0.6			0.6	0.5	0.5	1.3		0.5	0.5				
Carpsuckers					3.0	7.1	3.4	1.2	0.5	0.5				
Buffalos	2.5	2.8	1.3	0.6										
Temp. basses	1.2	4.9		1.7	1.0									
Sunfishes			3.2	0.6	2.0	1.0				1.1	2.2			
Crappies		2.1	4.5	1.1										
Darters	1.2													
Sauger		4.2												
Drum		0.7	3.9	20.0	54.9	76.7	26.2	6.0		0.5	0.5			
Damaged fish				1.1										
Total larvae	24.0	78.0	106.1	178.4	126.3	99.5	43.4	8.4	1.0	3.2	6.0	1.0	--	--
Effort (m^3)	163	144	155	175	199	210	233	167	202	189	183	97	78	108

Table 14

Relative Abundance (No./100 m^3) of Larval Fish (All Taxa) in the Lower Cracraft Dike Field, 1980

Stations	High River Stages 17 Apr	16 May	12 Jun	Moderate to Low River Stages 10 Jul	24 Jul	8 Aug	20 Aug	4 Sep	17 Sep	2 Oct	16 Oct
Above First Dike											
Nearshore	12	75	41	5	24	1	2	5	10	--	--
Offshore	13	72	84	14	NE†	6	NE	15	NE	--	NE
Below First Dike											
Nearshore	19	32	96	3	NE	11	NE	109	NE	1	NE
Offshore*	13	19	159								
Midpool**				9	NE	3	NE	6	NE	NE	NE
Poolside of Bar**				NE	NE	NE	NE	19	NE	NE	NE
Riverside of Bar**				8	NE	22	NE	14	NE	--	NE
Below Second Dike											
Nearshore	10	40	193	86	17	39	34	18	--	--	--
Offshore*	13	54	90								
Midpool**				64	5	29	25	2	--	--	--
Poolside of Bar**				42	6	88	46	--	--	--	--
Riverside of Bar**				17	6	3	5	3	15	--	--
Below Third Dike											
Upper Nearshore	17	13	60	42	--	9	54	9	--	--	--
Upper Offshore*	20	32	105								
Upper Midpool**				7	2	6	34	--	--	--	NE
Upper Poolside of Bar**				13	1	3	76	2	--	--	NE
Upper Riverside of Bar**				14	15	3	4	3	14	--	NE
Lower Nearshore	24	12	356	21	9	8	79	4	--	--	NE
Lower Offshore*	19	20	95								
Lower Midpool**				7	--	--	29	--	--	--	--
Lower Poolside of Bar**				23	2	5	1	1	--	--	--
Lower Riverside of Bar**				42	10	1	--	11	5	1	1
Parallel to Dikes											
Downstream of Second Dike	NE	96	NE	65	14	90	44	66	--	--	--
Upstream of Third Dike	NE	23	NE	6	15	14	62	9	--	--	--
Downstream of Third Dike	NE	25	NE	29	11	9	87	13	--	--	NE

* Not applicable at moderate to low river stages.
** Not applicable at high river stages.
† No effort.